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SHORT COMMUNICATION

Preliminary study of *Nicuatole*, a traditional endemic food based on *Zea mays* from the Central Valleys Region, Oaxaca, Mexico

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ABSTRACT

The present investigation evaluated the pre-Hispanic food called "nicuatole" based on corn, from the Central Valleys region of the state of Oaxaca, Mexico. The objective of the present work was to present preliminary results of the physicochemical and proximate properties of the pre-Hispanic food locally known as "nicuatole". The sample was prepared based on the traditional endemic recipe of the population of San Agustín Yatareni, Oaxaca, Mexico. To determine the physicochemical composition, samples of 10 g and 3 g were used for the tests (pH and density) and nutritional tests (moisture, proteins, lipids, minerals, and carbohydrates) based on the methods described by the Association of Official Analytical Chemistry (AOAC). As results, it was obtained that it has a pH of 6.18 and a density of 1.0812 g*mL^{-1}. The main results of the proximal analysis and chemical composition of "nicuatole" were 2.1325% protein; 1.54% ash; 66.3738% humidity content; 0.7563% lipids; 9.6271% carbohydrates; 13.1731% fiber. The pre-Hispanic food known as "nicuatole" can be considered a healthy alternative for the Mexican population.

Keywords: Pre-hispanic food; Nicuatole; *Zea mays*; Mexico; Dessert

INTRODUCTION

The corn grain is a caryopsis fruit, which includes the embryo, endosperm, aleurone and pericarp (Britannica, 2015). The color of the grain is an important factor in its classification since it is the result of the interaction between the pericarp, the aleurone and the endosperm (Broa-Rojas, 2019). The main component of the corn grain is starch, which corresponds to 72 to 73% of the weight of the grain. Carbohydrates present in the grain are simple sugars (glucose, sucrose, and fructose) in amounts that vary from 1 to 3%. Proteins are the second important component of grain; in common varieties their production varies from 8 to 11% of the weight of the grain and most of it is found in the endosperm. The grain lipids are found mainly in the germ with values ranging from 3 to 18%. The total dietary fiber in different varieties of corn is between 12 and 15% (Sheng, 2018; Ai, 2016). The ash content in the grain is approximately 1.3%, being the germ, which provides almost 78% of the minerals in the grain (Ramírez-Vega, 2022). The preferred corn for human consumption is white and smooth, although other types of corn are used in other areas of Mexico (Malvar-Pintos, 2006). In different areas of Oaxaca, corn cultivation has economic and cultural importance. Creole maize is the one that dominates the production of grain for self-consumption, and these are characterized by their genetic and morphological diversity. Only in the southern highlands of Oaxaca have been identified 36 traditional varieties corresponding to 10 agronomic races (García-Montesinos, 2020). The "nicuatole", is a pre-Hispanic dessert endemic to the state of Oaxaca, Mexico. It has a consistency like a custard, flan, or jelly (Fig. 1). It is a product made with creole corn, milk, water, sugar or piloncillo, and cinnamon.

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Fig 1. Per-Hispanic food"nicuatole".

During its pre-Hispanic production, it was poured into pots made from clay and grana cochineal was added to the final product to give it the characteristic red pigmentation (Islas, 2021). Its origin is so old that it goes back to the time of the Aztecs, where after a battle this food was offered as a reward to recover energy (Sigala, 2021). The objective of the present work was to present preliminary results of the physicochemical and proximate properties of the pre-Hispanic food locally known as "nicuatole".

MATERIALS AND METHODS

The sample was prepared based on the traditional endemic recipe of the population of San Agustín Yatareni, Oaxaca, Mexico. For the elaboration of the corn "nicuatole", 250 g of grams of creole corn were used (Zea mays), which was washed for the elimination of residues. Subsequently, it was cooked with water for 3 h at a temperature between 80-100 °C. After cooking, remove the water and reserve the corn. In a blender, the corn is poured with 100 mL of water, then it is transferred to a saucepan using a blanket as a filter, always recovering the liquid phase. The solid material is placed back in the blender with another 100 mL of water. Once the liquid (atole) is obtained, it is brought to a boil, adding 190 g of cane sugar and 8 g of cinnamon. Stirring constantly, when it reaches the boil, remove the cinnamon, and continue mixing until a solid consistency like that of a jelly is obtained. Once the desired consistency is obtained, it is removed from the heat and poured into containers for the placement of the red dye that is characteristic of this Oaxacan dessert. For the dye, mix 5 g of sugar and 1 g of cochineal red dye.

To determine the physicochemical composition, 10 g samples were used for the tests (pH and density) and nutritional (humidity, proteins, lipids, minerals, and carbohydrates) based on the methods described by the Association of Offical Analytical Chemistry (AOAC). Three repetitions were performed for all the variables studied.

pH determination

The determination of pH will be carried out using the electrometric method, which consists of determining the concentration produced by hydronium ions through potentiometric measurements using a glass electrode with a reference electrode that has been calibrated with standardized substances at a pH of 7 and 4.

Density determination

To determine the density, an indirect method will be chosen, which consists of weighing a certain amount of "nicuatole" on an analytical balance and obtaining its mass. To obtain the volume, the amount of nicuatole weighed will be submerged in a test tube with water (V_0) to obtain the volume of water that is displaced (V_1). The volume of the solid will correspond to the difference in volumes (V_1-V_0). The density will be calculated by dividing the mass by the volume.

Viscosity determination

To carry out the measurement of the viscosity of the "nicuatole" a Brookfield type viscometer will be used.

Humidity determination

The AOAC 930.15 method (AOAC, 2003) was used, approximately 3 g of "nicuatole" is weighed on an analytical balance and placed in an oven at 100 ± 5 °C for 24 hours, at the end of the time, the container is covered and placed in a desiccator for 5 minutes, then the final weight is recorded, and the percentage of moisture is determined by weight difference.

Ash determination

The AOAC 942.05 method (AOAC, 2003) was used, in a porcelain crucible of 15 mL of known weight, 3 g of "nicuatole" are weighed, then it is placed in a muffle at 600 °C for a time of 2 hours, at the end of the time it is removed and placed in a desiccator until it cools, recording its final weight, and by difference the ash content is calculated.

Protein determination

The AOAC 984.13 method (AOAC, 2003) was used, through the microkjeldhal method, for which approximately 0.5 g of sample is weighed in a 50 mL tube of the same name, then adding 2.5 mL of concentrated sulfuric acid, this is taken to a sand slab to colorless solution, allow to cool and distill with 40% sodium hydroxide in a volume of about 15 mL. The distillate is received in a 100 mL flask containing 5 mL of indicator for proteins (boric acid, methyl red and bromine cresol green) until it changes color from red to green, which indicates that the distillation process has ended. Finally, it is titrated with a 1N hydrochloric acid solution, until a red color change. The nitrogen content is determined and multiplied by the factor 6.25 to express the percentage of protein.

Determination of lipids using ether extract

The AOAC 920.039 method (AOAC, 2003) was used, 3 g of "nicuatole" is placed in a filter paper envelope, it is

placed in a Soxhlet tube. Then, in a 250 mL flask, 160 mL of hexane solvent is added, the equipment is assembled with the refrigerant on an electric cooker, the lipids are extracted for a period of 2 to 4 hours. After that time, the envelope is removed and the solvent is recovered until only the extracted remain in the flask, then it is taken to an oven at 60 °C for complete evaporation of the solvent (Fig. 2). The balloon containing the fat is weighed and the content is determined by weight difference.

Determination of total sugars

To carry out this test, a sample of the food should be taken and placed in 250 mL Erlenmeyer flasks. To each of the flasks should be added 50 mL of distilled water, in addition to 5 mL of a saturated lead acetate solution; the flask should be shaken until a homogeneous substance is obtained. This solution obtained must be filtered and washed 3 times with 10 mL of distilled water, the filtrate obtained will be deposited in another Erlenmeyer flask to which 2 g of potassium oxalate will be added, this will be mixed again homogeneously to pass to a filtration. After filtration, the flask is washed 3 times with 10 mL of distilled water. 5 mL of HCl will be added to the final filtrate and it will be placed in a water bath with constant heating for 15 minutes at 68 °C. The result of the procedure will give us an acid solution, for which it must be neutralized with a 10% NaOH solution to obtain a pH of 6.5 to 7.5. When the substances are neutralized, they will be transferred to a 250 ml volumetric flask to which the missing volume will be completed with distilled water. Taking the volumetric flasks, they will be shaken to obtain a homogeneous mixture, the contents of the flask will be transferred to a 50 ml burette with which a titration will be carried out. Para llevar a cabo la titulación, en un matraz Erlenmeyer de 250 ml se colocarán 5 ml de sustancia A de Fehling, 5 ml de sustancia B de Fehling, 50 ml de agua destilada y 10 gotas de azul de metileno como indicador. To carry out the titration, place 5 ml of Fehling's substance A, 5 ml of Fehling's substance B, 50 ml of distilled water and 10 drops of methylene blue as indicator in a 250 ml Erlenmeyer flask. The flask shall be brought to a constant boil before starting the titration.

Fig 2. Determination of lipids using ether extract.

Fiber determination

Approximately 3 g of sample will be weighed and placed in a container where 200 mL of previously heated H_2SO_4 will be poured. The containers will be brought to a constant boil for 30 minutes. Once the time has elapsed, it is filtered and washed using boiled distilled water; the containers will be washed with NaOH at a normality of 0.013. After the washes, 3 washes will be carried out with hot distilled water. At the end, the containers will be moved to an oven with a temperature of 100 °C for a period of 3 hours. After the time, the containers with samples are moved to a muffle until a temperature of 420 °C is reached, once the temperature is reached, they are left to rest to be moved to a desiccator with non-hydrated desiccant for approximately 15 to 30 minutes and the fiber content is calculated by difference.

RESULTS

For the determination of pH, a potentiometer (HANNA, HI2215 pH/ORP) was used, before being used it was calibrated with pH 7 and 4 blanks. With the calibrated potentiometer the reading was taken, obtaining a pH of 6,18 at a temperature 28,8°C.

To obtain the density of the product, a density study was carried out by volume displacement. For this, 0,8109 g of "nicuatole" sample was taken, which was poured into a 10 ml test tube containing 5 ml of distilled water. The volume reading was 5.75 ml when adding the sample. The density value is 1.0812 $g*mL^{-1}$.

The results obtained in the proximal analysis are shown in Table 1, which highlights the protein content obtained as well as the high fiber content available, in addition, there is a low-fat content. As for humidity, the value obtained is expected for this type of food.

DISCUSSION

The nutritional transition that is observed today in our society refers to the changes that occur when income

Table 1: Proximal chemical analysis obtained from "nicuatole"

% humidity	66.3738
% ash	1.5400
% protein	2.1325
% fiber	13.1731
% lipids	0.7563
% carbohydrates	9.6271

Table II: Nutritional comparison of powdered jellies available on the market

Mark	Protein [g]	Lipids [g]	Carbohydrates [g]	Energy supply [Kcal]
"Aurrera"	1.85	-	12.13	56
"D'Gary"	2.35	-	10.53	52
"Jell-O"	1.99	-	0.33	9
"Pronto" (reduced in sugar)	2.03	-	7.35	37

Source: (PROFECO, 2018)

increases in a family, community, or population. What it brings with it, a change in diet for a so-called modern diet in which the high consumption of saturated fats, sugars, animal proteins, low in fibers, and increased consumption of processed foods predominates. Inadequate food intake (both in quantity and quality), results in poor nutrition, which is associated with certain diseases and an increased risk of various diseases (Ortiz, 2005; Bruno-Fiscal, 2016). In Table 2, the nutritional comparison of the gelatin brands that are distributed in the Mexican market is established, highlighting the high content of simple sugars, in addition to their protein content. The protein content of the pre-Hispanic dessert "nicuatole" is on a par with the protein content offered by them, it should be noted that it is protein of vegetable origin. The "nicuatole" has its formulation base in corn (Zea mays), which is rich in the amino acids' cysteine, methionine, threonine, and tryptophan, in addition to presenting a high amount of vitamin B3 derived from the nixtamalization process, which is a preliminary step for the preparation of "nicuatole" (Caire-Juvera, 2013; Woolf, 2011). Being a product derived from corn, it can be considered that nicuatole has the active peptides that it naturally possesses and that exert their biological activity after their enzymatic release or chemical hydrolysis (Quesada, 2019; Richter, 2015; García, 2013; Sarmadi, 2010; Mulero, 2011; Maki, 2012). These peptides can act as immunomodulatory, antithrombotic, hypocholesterolemic, anti-inflammatory, antimicrobial, antihypertensive, vasoregulatory, antioxidant, hormone-inducing, and neurotransmitter factors (García, 2013; Sarmadi, 2010; Mulero, 2011). The fiber content that this food can condition the speed of absorption of starch or simple sugars. The fiber present in cereals such as corn can be beneficial for health since the intake of functional fiber can multiply by ten the numerical representation of bifidobacteria (Escudero-Álvarez, 2006; Bouhnik, 1996), in what has been called the prebiotic effect: non-digestible components of the diet that are beneficial to the host because they produce the selective growth and/or activity and/or of one or a limited number of bacteria in the colon (Gibson, 1995; Gibson, 2004). However, the disadvantage that this food can present is due to the gelatinization of the starch since they are hydrolyzed more quickly. This is because the granule can irreversibly lose its crystalline structure, causing an increase in viscosity, facilitating the attack of intestinal enzymes during the digestive process, resulting in an increase in the glycemic index of the food.

CONCLUSIONS

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Conflicts of interest

The authors declare no conflict of interest.

Author contributions

Morales-Sánchez José Luis participated in the conception, design, collection, analysis and interpretation of the data. Hernández-Bautista Emilio participated in the collection, analysis, and interpretation of data. Matías-Pérez Diana participated in the development of the draft (first version). Pérez-Santiago Alma Dolores and Sánchez-Medina Marco Antonio participated in the conception and design of the study, as well as in the critical review of the article with important contributions to its intellectual content. García-Montalvo Iván Antonio participated in the study concept, design, writing, and critical review of the manuscript.

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